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(71) Applicant: **Yamatate Corporation**
Tokyo 100-6419 (JP)

(72) Inventors:
• **SHIMAKATA, Tetsuya**
Tokyo 100-6419 (JP)
• **EGAWA, Miho**
Tokyo 100-6419 (JP)

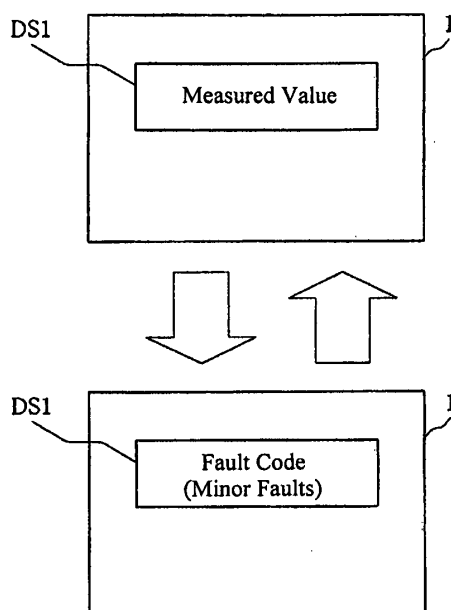
(74) Representative: **Tomlinson, Kerry John**
Dehns
St Bride's House
10 Salisbury Square
London
EC4Y 8JD (GB)

(54) **MEASURING APPARATUS**

(57) When a major failure is detected, display of a measurement value on a display section (DS1) is stopped, and instead of the measurement value, an abnormal code, which indicates the contents of the major

failure, is displayed on the display section (DS1). When a minor failure is detected, an abnormal code, which indicates the contents of the minor failure, and a measurement value are alternately displayed on the display section (DS1) by being switched one from the other.

FIG. 3



Description

TECHNICAL FIELD

[0001] The present invention relates to a measuring device for measuring and displaying a specific physical quantity such as a differential pressure.

BACKGROUND OF THE INVENTION

[0002] Conventionally, measuring devices, such as differential pressure transmitting devices that measure differential pressures, have been installed in on-site processes and have detected specific physical quantities, and have display units for calculating and displaying measured values based on the physical quantities that have been detected.

[0003] Among this type of measuring device there are sophisticated devices that have diagnostic functions for detecting various types of faults, where, if some sort of fault has been detected by the diagnostic function, a fault code, that indicates the type of fault, is displayed on the display unit.

[0004] As a method for displaying the fault code in such a case, a display method may be used wherein, for example, a display unit DS1 for the measured value and a separate display unit DS2, for the fault code, are provided, as illustrated in, for example, FIG. 17, and the fault code is displayed on the display unit DS2. (*see e.g.*, Patent Reference 1 (Japanese Unexamined Patent Application Publication 2000-248967).)

DISCLOSURE OF THE INVENTION

PROBLEMS THAT THE INVENTION IS TO SOLVE

[0005] However, in the method for displaying fault codes as illustrated in FIG. 17, there is the need to provide a fault code display unit DS2 that is separate from the measured value display unit DS1, which is costly.

[0006] Additionally, in the method for displaying fault codes as illustrated in FIG. 17, the measured value is displayed continuously on the display unit DS1, regardless of the type of fault that has been detected. In this case, as the types of faults, there are faults that have an impact on the reliability of the measured value (major faults (type 1 faults)), and faults that have no impact on the reliability of the measured value (minor faults (type 2 faults)). In the case of the major faults, even if a measured value is displayed, the measured value is meaningless, and, conversely, displaying a measured value that has no reliability may cause problems in that it may cause observer to draw incorrect understandings.

[0007] In contrast, one may consider a display method wherein there is only a single display unit DS1 for the measured value, as illustrated in FIG. 18, and some sort of fault is detected, then the display of the measured value by the display unit DS1 is terminated and, instead of

the measured value, the fault code is displayed on the display unit DS1. This makes it possible to get by with only a single display unit, which is less expensive.

[0008] However, in the display method for the fault code illustrated in FIG. 18, the display of the measured value by the display unit DS1 is terminated regardless of the type of fault and that has been detected, and the fault code is displayed on the display unit DS1 instead of the measured value. In this display method, the unreliable measured value will not be displayed in the case of a major fault, and thus the observer will not be given an incorrect understanding. However, in the case of a minor fault, the display of the measured value is terminated, regardless of there being some degree of reliability in the measured value and regardless of its usefulness in analyzing the fault, which becomes an impediment in monitoring the measured values.

[0009] The present invention is made to solve the above-described problems, and it is an object of the present invention to provide a measuring device that enables continuous monitoring of a measured value when a minor fault has occurred, and that can be configured with a single display unit for information indicating the measured value and the details of the fault.

MEANS FOR SOLVING THE PROBLEMS

[0010] The present invention, in order to achieve the object as set forth above, includes:

a sensor that detects a specific physical quantity; a calculator that calculates a measured value based on the physical quantity detected by the sensor; a fault detector that detects a first fault and a second fault, wherein the first fault has an influence on the reliability of the measured value and the second fault does not have an influence on the reliability of the measured value; a display unit that displays at least one of the measured value, information indicating the content of the first fault and information indicating the content of the second fault; and a display controller that: controls the display unit so as to display, instead of the measured value, the information indicating the content of the first fault, when the fault detector detects the first fault; and controls the display unit so as to display the measured value and the information indicating the content of the second fault, when the fault detector detects the second fault.

[0011] According to this invention, when the first fault (wherein, in the below, this fault may also be referred as to a "major fault" for convenience in the present invention) has occurred, information indicating the content of the major fault is displayed on a single display unit instead of the measured value. When the second fault (wherein, in the below, this may also be referred as to a "minor fault" for convenience in the present invention) has oc-

curred, information indicating the content of the minor fault is displayed along with the measured value on the single display device.

ADVANTAGE OF THE INVENTION

[0012] According to the present invention, when a major fault (the first fault) has occurred, information indicating the content of the major fault is displayed, instead of the measured value, on a single display unit, and when a minor fault (the second fault) has occurred, information indicating the content of the minor fault is displayed, together with the measured value, on the single display unit, and thus a display unit for the measured value and for the information indicating the content of the fault can be made inexpensively as a single unit, and the monitoring of the measured value can be continued when a minor fault has occurred.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

FIG. 1 is a diagram for explaining a first example display of a fault code in a measuring device according to the present invention (a diagram illustrating the case wherein no fault has occurred).

FIG. 2 is a diagram for explaining a first example display of a fault code in a measuring device according to the present invention (a diagram illustrating a case wherein a major fault (a type 1 fault) has occurred).

FIG. 3 is a diagram for explaining a first example display of a fault code in a measuring device according to the present invention (a diagram illustrating a case wherein a minor fault (a type 2 fault) has occurred).

FIG. 4 is a diagram for explaining an example wherein extra display digits are provided for the measured value to display information indicating the details of the minor faults.

FIG. 5 is a diagram for explaining an example display of a fault code (second example display (in a case wherein major faults of a plurality of types have been detected)) when faults of a plurality of types have been detected.

FIG. 6 is a diagram for explaining an example display of a fault code (second example display (first example of a case wherein minor faults of a plurality of types have been detected)) when faults of a plurality of types have been detected.

FIG. 7 is a diagram for explaining an example display of a fault code (second example display (second example of a case wherein minor faults of a plurality of types have been detected)) when faults of a plurality of types have been detected.

FIG. 8 is a diagram for explaining an example display of a fault code (second example display (third exam-

ple of a case wherein minor faults of a plurality of types have been detected)) when faults of a plurality of types have been detected.

FIG. 9 is a diagram for explaining an example display of a fault code (second example display (fourth example of a case wherein minor faults of a plurality of types have been detected)) when faults of a plurality of types have been detected.

FIG. 10 is a diagram for explaining an example display of a fault code (third example display) when a mixture of major faults and minor faults has been detected.

FIG. 11 is a diagram illustrating schematically the hardware configuration of a differential pressure transmitter.

FIG. 12 is a diagram illustrating a display pattern in a liquid crystal display unit of the differential pressure transmitter.

FIG. 13 is a diagram for illustrating major fault diagnostic items that are executed by the diagnostic program, and fault codes that are outputted when major faults are detected.

FIG. 14 is a diagram for illustrating minor fault diagnostic items that are executed by the diagnostic program, and fault codes that are outputted when minor faults are detected.

FIG. 15 is a flow chart illustrating the distinctive processing operations executed by the CPU of the differential pressure transmitter.

FIG. 16 is a functional block diagram of the critical portions of the differential pressure transmitter.

FIG. 17 is a diagram for explaining a conventional fault code displaying method.

FIG. 18 is a diagram for explaining a display method for a fault code that is generally considered when installing only a display unit for the measured value.

BEST MODE FOR CARRYING OUT THE INVENTION

[0014] The present invention will be explained in detail below, based on the drawings.

(Display Example 1)

[0015] FIG. 1 through FIG. 3 are diagrams for explaining a first example of a display of fault codes in a measuring device according to the present invention. FIG. 1 illustrates the case wherein no fault has occurred, FIG. 2 illustrates the case wherein the fault that has an influence on the reliability of the measured data (a major fault (a type 1 fault)) has occurred, and FIG. 3 illustrates a case wherein a fault that does not influence the reliability of the measured value (a minor fault (a type 2 fault)) has occurred.

[0016] In the first example display, the measuring device is a differential pressure transmitter 1, where only a display unit DS1 for the measured value is provided in the differential pressure transmitter 1. (see FIG. 1.) The

differential pressure transmitter 1 has a diagnostic function for detecting various types of faults, where major faults and minor faults are detected by this diagnostic function.

(Example of Display when a Major Fault Has Been Detected)

[0017] When a major fault has been detected, the differential pressure transmitter 1 terminates the display of the measured value on the display unit DS1, and instead of the measured value, displays, on the display unit DS1, a fault code that indicates the detail of the major fault. (See FIG. 2.) The differential pressure transmitter 1 displays continuously the fault code that indicates the detail of the major fault during the interval over which the major fault is detected.

(Example of Display when a Minor Fault Has Been Detected)

[0018] When a minor fault has been detected, the differential pressure transmitter 1 alternately switches between displaying a fault code that indicates the detail of the minor fault and displaying the measured value on the display unit DS1. (see FIG. 3.) Over the interval over which the minor fault is detected, the differential pressure transmitter alternately switches between the fault code that indicates the minor fault and the measured value.

[0019] This type of fault code displaying method makes it possible to configure the display unit for the measured value and for information indicating the detail of the failure as a single display unit, and makes it possible to monitor the measured value continuously, even when a minor fault has occurred.

[0020] In this first example display, if a minor fault has occurred, then the fault code that indicates the detail of the minor fault and the display value are displayed switched alternately on the display unit DS1; however, as illustrated in FIG. 4, extra display digits for the measured value may be provided in the display unit DS1, or in other words, extra digits 1b, in addition to the display digits 1a for the measured value, may be provided, and information indicating the detail of the minor fault may be displayed in these extra digits 1b that are provided.

[0021] In the example illustrated in FIG. 4, of the fault codes that indicate the detail of the minor fault, the letters "AL", indicating that there is a minor fault, are displayed. The letters "AL", indicating that this is a minor fault, are included in the definition of information that indicates the detail of a type 2 fault (a minor fault) in the present invention.

(Display Example 2: When Faults of Multiple Types Are Detected)

[0022] In the first example display, the discussion was for discriminating between a major fault and a minor fault;

however, there are various types of major faults and minor faults. That is, major faults of multiple types may be detected, and minor faults of multiple types may be detected.

(When Multiple Types of Major Faults Are Detected)

[0023] FIG. 5 is a diagram illustrating an example display of a fault code on the display unit DS1 when major faults of multiple types have been detected. When no fault has occurred, then the differential pressure transmitter 1 displays the measured value on the display unit DS1 (A). Here, assume that two types of major faults, major fault 1 and major fault 2, are detected.

[0024] In this case, the differential pressure transmitter 1 terminates the display of the measured value on the display unit DS1, and instead of the measured value, displays, on the display unit DS1, the fault code "ERR 01", indicating the detail of the major fault 1 (B). Then, after a specific time interval has elapsed, the display unit DS1 is given a blank display (C) over a specific time interval. Then, after this interval of a blank display, the fault code "Err. 02", indicating the detail of the major fault 2, is displayed on the display unit DS1 (D). Then, after a specific time interval has elapsed, the display unit DS1 is given a blank display over a specific time interval (E), after which the display of the fault code "Err. 01", indicating the detail of the major fault 1, is restored (B). The same operation is repeatedly performed thereafter.

[0025] Repeating this type of operation causes the fault code "Err. 01", which indicates the detail of the major fault 1, and the fault code "Err. 02", which indicates the detail of the major fault 2, to be displayed alternately on the display unit DS1, with blank display intervals interposed therebetween.

[0026] This makes it possible to provide clear notification of the distinction between the fault code indicating the detail of the major fault 1 and the fault code indicating the detail of the major fault 2 through enhancing the difference in the content of the display by interposing the blank display intervals therebetween.

[0027] That is to say, if there were no blank display time interval, then if, for example, "Err. 06" were displayed for the fault code that indicates the detail of the major fault 1 and, for example, "Err. 08" were displayed for the fault code that indicates the detail of the major fault 2, then the part that changes is small, and thus there is a risk that the change of the code may be overlooked. In contrast, a blank display interval is provided in switching the fault code, and thus it is possible to provide a clear notification that there is a change in the fault code, thereby making it possible to eliminate the risk that the change in the code will be overlooked.

[0028] In this example, for simplicity in the explanation, it was assumed that two types of major faults, major fault 1 and major fault 2, had been detected, but even when more types of major faults have been detected, still the fault codes that indicate the details of the major faults

that have been detected may be displayed, switching sequentially, in the same manner on the display unit DS1, with blank display intervals interposed therebetween.

(When Multiple Types of Minor Faults Are Detected (First Example))

[0029] FIG. 6 is a diagram illustrating an example display of a fault code on the display unit DS1 when minor faults of multiple types have been detected (first example). When no fault has occurred, then the differential pressure transmitter 1 displays the measured value on the display unit DS1 (A). Here, assume that two types of minor faults, minor fault 1 and minor fault 2, are detected.

[0030] In this case, the differential pressure transmitter 1 interrupts the display of the measured value on the display unit DS1, and displays, on the display unit DS1, the fault code "AL. 01", indicating the detail of the minor fault 1 (B). Then, after a specific time interval has elapsed, the display unit DS1 displays the measured value over a specific time interval (C). Then, after this display of the measured value, the fault code "AL. 02", indicating the detail of the minor fault 2, is displayed on the display unit DS1 (D), and after a specified amount of time has elapsed, the display of the measured value is restored (A). The same operation is repeatedly performed thereafter.

[0031] Repeating this type of operation causes the fault code "AL. 01", which indicates the detail of the minor fault 1, and the fault code "AL. 02", which indicates the detail of the minor fault 2, to be displayed alternately on the display unit DS1, with the measured value interposed therebetween.

[0032] This makes it possible to provide clear notification of the distinction between the fault code indicating the detail of the minor fault 1 and the fault code indicating the detail of the minor fault 2 through enhancing the difference in the content of the display by interposing the measured value display intervals therebetween.

[0033] That is to say, if there were no interposed measured value time intervals, then if, for example, "AL. 06" were displayed for the fault code that indicates the detail of the minor fault 1 and, for example, "AL. 08" were displayed for the fault code that indicates the detail of the minor fault 2, then the part that changes is small, and thus there is a risk that the change of the code may be overlooked. In contrast, the interposition of the measured value intervals when switching the fault code provides a clear notification that there is a change in the fault code, making it possible to eliminate the risk that the change in the code will be overlooked.

[0034] In this example, for simplicity in the explanation, it was assumed that two types of minor faults, minor fault 1 and minor fault 2, had been detected, but even when more types of minor faults have been detected, still the fault codes that indicate the details of the minor faults that have been detected may be displayed, switching sequentially, in the same manner on the display unit DS1,

with measured value interposed therebetween.

(When Multiple Types of Minor Faults Are Detected (Second Example))

[0035] FIG. 7 is a diagram illustrating another example display of a fault code on the display unit DS1 when minor faults of multiple types have been detected (second example). When no fault has occurred, then the differential pressure transmitter 1 displays the measured value on the display unit DS1 (A). Here, assume that two types of minor faults, minor fault 1 and minor fault 2, are detected.

[0036] In this case, the differential pressure transmitter 1 interrupts the display of the measured value on the display unit DS1, and displays, on the display unit DS1, the fault code "AL. 01", indicating the detail of the minor fault 1 (B). Then, after a specific time interval has elapsed, the display unit DS1 is given a blank display (C) over a specific time interval. Then, after this blank display interval, the fault code "AL. 02", indicating the detail of the minor fault 2, is displayed on the display unit DS1 (D), and after a specified amount of time has elapsed, the display of the measured value is restored (A). The same operation is repeatedly performed thereafter.

[0037] Repeating this type of operation causes the measured value and a group of fault codes indicating the details of the minor faults to be displayed switching alternately on the display unit DS1. In the group of fault codes that indicate the details of the minor faults, the fault code "AL. 01", which indicates the detail of the minor fault 1, and the fault code "AL. 02", which indicates the detail of the minor fault 2, to be displayed alternately, with blank display intervals interposed therebetween.

[0038] This makes it possible to provide clear notification of the distinction between the fault code indicating the detail of the minor fault 1 and the fault code indicating the detail of the minor fault 2 through enhancing the difference in the content of the display by interposing the measured value display intervals therebetween, or through enhancing the difference in the content of the display through the position of the blank display intervals.

[0039] In this example, for simplicity in the explanation, it was assumed that two types of minor faults, minor fault 1 and minor fault 2, had been detected, but even when more types of minor faults have been detected, still the measured value and the group of fault codes that indicate the details of the minor faults may be displayed alternately, switching sequentially in the group of the fault codes that indicate the details of the minor faults, to display the fault codes that indicate the details of the minor faults, in the same manner, on the display unit DS1, with blank display intervals interposed therebetween.

(When Multiple Types of Minor Faults Are Detected (Third Example))

[0040] While, in the example illustrated in FIG. 6, a blank display interval was provided between the interval

for displaying the measured value and the interval for displaying the fault code that indicates the detail of the minor fault, a blank display interval may be provided therebetween, as illustrated in FIG. 8.

(When Multiple Types of Minor Faults Are Detected (Fourth Example))

[0041] While, in the example illustrated in FIG. 7, a blank display interval was provided between the interval for displaying the measured value and the interval for displaying the fault code that indicates the detail of the minor fault, a blank display interval may be provided therebetween, as illustrated in FIG. 9.

(Display Example 3: Major Faults and Minor Faults Mixed Together)

[0042] In display examples 1 and 2, an example of a display for when only major faults were detected and an example of a display for when only minor faults were detected were explained. In practice, major faults and minor faults may be mixed together. When a major fault has occurred, the measured value will be unreliable, regardless of how many minor faults have occurred.

[0043] In consideration of this, in the third example display, it is only when all of the faults that are detected are minor faults that the fault codes that indicate the details of the minor faults will be displayed using the methods as explained in FIG. 6 through FIG. 9, and when major faults and minor faults are mixed together, then the fault codes indicating the details of the major faults and the fault codes indicating the details of the minor faults will be displayed on the display unit DS1 with blank display intervals interposed therebetween.

[0044] FIG. 10 is a diagram for explaining an example display of a fault code when a mixture of major faults and minor faults has been detected, and when no fault has been detected, the differential pressure transmitter 1 displays the measured value of the display unit DS1 (A). Here, assume that two types of major faults, major fault 1 and major fault 2, are detected and that two types of minor faults, minor fault 1 and minor fault 2, are detected.

[0045] In this case, the differential pressure transmitter 1 terminates the display of the measured value on the display unit DS1, and instead of the measured value, displays, on the display unit DS1, the fault code "Err. 01", indicating the detail of the major fault 1 (B). Then, after a specific time interval has elapsed, the display unit DS1 is given a blank display (C) over a specific time interval. Then, after this blank display interval, the fault code "Err. 02", indicating the detail of the major fault 2, is displayed on the display unit DS1 (D), and after a specified amount of time has elapsed, a blank display interval is caused on the display unit DS1 (E).

[0046] Next, in the differential pressure transmitter 1, the fault code "AL. 01", indicating the detail of the minor fault 1, is displayed on the display unit DS1 (F), and after

a specified amount of time has elapsed, a blank display interval is caused on the display unit DS1 (D). Then, after this blank display interval, the fault code "AL. 02", indicating the detail of the minor fault 2, is displayed on the display unit DS1 (H), after a specified amount of time has elapsed, a blank display interval is caused on the display unit DS1 (I), after which the fault code "Err. 01", indicating the detail of the major fault 1, is restored (B). The same operation is repeatedly performed thereafter.

[0047] Repeating this type of operation causes the fault code "Err. 01", which indicates the detail of the major fault 1, the fault code "Err. 02", which indicates the detail of the major fault 2, the fault code "AL. 01", which indicates the detail of the minor fault 1, and the fault code "AL. 02", which indicates the detail of the minor fault 2, to be displayed switching sequentially on the display unit DS1, with a blank display interval interposed therebetween.

[0048] This makes it possible to provide clear notification of the distinction between the fault code indicating the detail of the major fault 1 and the fault code indicating the detail of the major fault 2 through enhancing the difference in the content of the display, and of the distinction between the fault code indicating the detail of the minor fault 1 and the fault code indicating the detail of the minor fault 2 through enhancing the difference in the content of the display, through the interposition of the blank display intervals therebetween.

[0049] While there has been described the example in which the fault codes for the group of major faults are displayed and then the fault codes for the minor faults are displayed, instead, it is possible that the fault codes for the group of minor faults are displayed and then the fault codes for the major faults are displayed, or it is possible that the fault codes for the group of major faults and the fault codes for the minor faults may be displayed mixed with each other.

[0050] Furthermore, while in this example, for simplicity in the explanation, it was assumed that two types of major faults, major fault 1 and major fault 2, had been detected for the major faults, and two types of minor faults, minor fault 1 and minor fault 2, had been detected for the minor faults, even when more types of major faults and minor faults have been detected, still the fault codes that indicate the details of the major faults and fault codes that indicate the details of the minor faults that have been detected may be displayed, switching sequentially, in the same manner on the display unit DS1, with blank display intervals interposed therebetween.

(Example of Embodiment 1)

[0051] The processing operations in the differential pressure transmitter 1 will be explained in detail for the example in the third display example, described above. FIG. 11 illustrates schematically the hardware configuration of the differential pressure transmitter 1. In this figure, 1-1 is a CPU, 1-2 is a RAM, 1-3 is a ROM, 1-4 is

an NVM (Non-Volatile Memory), 1-5 is a liquid crystal display unit, S1 is a differential pressure sensor, S2 is a static pressure sensor, S3 is a temperature sensor, and 1-6 through 1-8 are A/D converters. The differential pressure transmitter 1 further includes the constituent elements of the differential pressure sensor S1, the static pressure sensor S2, and the temperature sensor S3.

[0052] The CPU 1-1 receives a signal indicating the static pressure from the static pressure sensor S1 through the A/D converter 1-6, a signal indicating the static pressure from the static pressure sensor S2 through the A/D converter 1-7, and a signal indicating the temperature through the A/D converter 1-8. While accessing the RAM 1-2 and the NVM 1-4, CPU 1-1 performs operations in accordance with a program that is stored in the ROM 1-3.

[0053] The ROM 1-3, stores, as programs that are unique to the present example of embodiment, a measured value displaying program for calculating, and displaying on the liquid crystal display unit 1-5, a measured value by performing various types of calculation processes on the signal indicating the differential pressure from the differential pressure sensor S1, a diagnostic program for detecting various types of faults, defined in advance, and a fault code displaying program for displaying fault codes on the liquid crystal display unit 1-5 based on the results of diagnostics in accordance with the diagnostic program.

[0054] FIG. 12 illustrates a display pattern in the liquid crystal display unit 1-5. In this display pattern, AR1 is a display region for the measured value, AR2 is a display region for various types of supplemental information, and AR3 is a display region for displaying a bar graph of measured values, where the display region AR1 has, as its critical structural elements, 7-segment groups, and the display region AR2 has, as its critical structural elements, 16-segment groups. In this display pattern, the display region AR1 corresponds to the display unit DS1 in the third example display.

[0055] FIG. 13 shows major fault diagnostic items that are executed by the diagnostic program, and fault codes that are outputted when major faults are detected. FIG. 14 shows minor fault diagnostic items that are executed by the diagnostic program, and fault codes that are outputted when minor faults are detected. In FIG. 13 and FIG. 14, the diagnostic items are displayed in order of priority. In the present example of embodiment, detail table TB1, as illustrated in FIG. 13, and detail table TB2, as illustrated in FIG. 14, are stored in the ROM 1-3.

[0056] The flow chart illustrated in FIG. 15 will be referred to explain the processing operations performed by the CPU 1-1 in accordance with the diagnostic program and the fault code displaying program stored in the ROM 1-3. The flow chart illustrated in FIG. 15 illustrates the overall processing operations that are performed in co-operation by the diagnostic program and the fault code displaying program.

[0057] The CPU 1-1 executes the diagnostic program

to check for a normal/fault state for each of the diagnostic items (Step S101). Here, if there are neither major faults nor a minor faults, and all is normal (Step S101: Normal), then the measured value that is obtained by the measured value displaying program is displayed on the liquid crystal display unit 1-5 (Step S102).

[0058] In contrast, if there is a major fault or a minor fault, and a determination is made that there is a fault (Step S101: Fault), then a check is made as to whether or not a major fault is included in the faults (Step S103). Here if all of the faults are minor faults, and there are no major faults included (Step S103: No), then, as illustrated in FIG. 6, for example, the fault codes that indicate the details of the minor faults are displayed, switching sequentially, on the display area AR1 (DS1) of the liquid crystal display unit 1-5, with the measured value interposed therebetween (Step S104). In this case, the fault codes that indicate the details of the minor faults are displayed in the sequence of priority in accordance with the table TB2, illustrated in FIG. 14.

[0059] If even a single major fault is included (Step S103: Yes), then, as illustrated in FIG. 10, for example, the display of the measured value is terminated, and the fault codes that indicate the details of the major faults and the fault codes that indicate the details of the minor faults are displayed sequentially, in the display area AR1 (DS1) of the liquid crystal display unit 1-5, with blank display intervals interposed therebetween (Step S105). In this case, the fault codes that indicate the details of the major faults are displayed in sequence of priority, in accordance with table TB1, illustrated in FIG. 13, and the fault codes that indicate the details of the minor faults are displayed in sequence, in order of priority, in accordance with table TB2, illustrated in FIG. 14. The fault codes that indicate the details of the major faults may be displayed alone, rather than displaying the fault codes that indicate the details of the minor faults.

[0060] While in the first example of embodiment, the display region AR1 for the measured value in the liquid crystal display unit 1-5 was of 7-segment groups, it may instead be 16-segment groups. In a seven-segment group it is possible to display several alphabetic characters in addition to the 10 numeric characters, but the number thereof is limited. With 16 segments, it is possible to further expand the number of characters that can be displayed.

[0061] Additionally, a segment method need not necessarily be used, but rather an LCD of a dot matrix method may be used instead. The use of the segment method, such as a 7-segment group or a 16-segment group, is able to reduce power consumption, and the configuration is inexpensive.

[0062] Additionally, while in the first example of embodiment a liquid crystal display unit was used for the display unit 1-5, instead a display unit that uses light-emitting diodes (LEDs), cold cathode lighting, fluorescent light tubes, incandescent filaments, or the like, may be used.

[0063] Additionally, in the first through third example displays and in the first example of embodiment, a blank displayed interval is provided. However, instead of this, the displayed may be flashed immediately after the display is switched.

For example, if the display interval for one fault code is 3 seconds, then for the first second immediately after the display is switched, the display may be flashed at 0.25 second intervals, and lit for the remaining 2 seconds.

For example, when a dot matrix liquid crystal is used, then the display may be displayed in reverse video each time the display is changed, and if a color liquid crystal is used, then the color may be changed each time the display is changed.

In these systems there is no need to provide the blank displayed interval when the display is switched, but the noticeability is higher when combined with the blank display interval.

[0064] Additionally, in the first through third example displays and in the first example of embodiment, the information that indicates the details of the faults, either major faults or a minor faults, need not necessarily be fault codes, but may instead be messages that display the details of the faults in actual text, or may be images displaying the details of the faults.

[0065] FIG. 16 illustrates a functional block diagram of the critical components of a differential pressure transmitter 1 in the first example of embodiment. The differential pressure transmitter 1 is provided with a calculating unit 1A for calculating a measured value for a differential pressure, a display unit 1B, a fault detecting unit 1C, and a display controlling unit 1D.

[0066] The calculating unit 1A obtained measured values for differential pressures by performing specific calculating processes with a signal from the differential pressure sensor S1 as the input. The measured value for the differential pressure is displayed by the calculating unit 1A onto the display unit 1B. The fault detecting unit 1C detects various types of faults by inputting a signal indicating the differential pressure from the differential pressure sensor S1, a signal indicating the static pressure from the static pressure sensor S2, and a signal indicating the temperature from the temperature sensor S3.

[0067] The display controlling unit 1D, when, based on the faults detected by the fault detecting unit 1C, there is even one major fault in the faults, displays on the display unit 1B, instead of the measured value, the fault codes that indicate the details of the major faults and the fault codes that indicate the details of the minor faults, switched sequentially with blank display intervals interposed therebetween, and if all of the faults are minor faults, then the fault codes indicating the details of the minor faults are displayed on the display unit 1B along with the measured values. The calculating unit 1A, the fault detecting unit 1C, and the display controlling unit 1D are achieved as processing functions of the CPU 1-1.

[0068] In the configuration illustrated in FIG. 16, one may consider also a case wherein the differential pres-

sure sensor S1 or the static pressure sensor S2 is not provided. In this case, the calculating unit 1A converts into a measured value, to be displayed on the display unit 1B, the differential pressure detected by the differential pressure sensor S1. The conversion into the measured value from the differential pressure by the calculating unit 1A is included in the calculations by the calculating means referenced in the present invention.

10 INDUSTRIAL APPLICABILITY

[0069] The measuring device according to the present invention is not limited to a differential pressure transmitter, but rather may be applied also to odometers and trip meters equipped in automobiles, and the like.

Claims

20 1. A measuring device comprising:

- a sensor that detects a specific physical quantity;
- a calculator that calculates a measured value based on the physical quantity detected by the sensor;
- a fault detector that detects a first fault and a second fault, wherein the first fault has an influence on the reliability of the measured value and the second fault does not have an influence on the reliability of the measured value;
- a display unit that displays at least one of the measured value, information indicating the content of the first fault and information indicating the content of the second fault; and
- a display controller that:

controls the display unit so as to display, instead of the measured value, the information indicating the content of the first fault, when the fault detector detects the first fault; and
controls the display unit so as to display the measured value and the information indicating the content of the second fault, when the fault detector detects the second fault.

2. The measuring device as set forth in Claim 1, wherein the display controller allows the display unit to display the information indicating the content of the detected second fault and the measured value by alternatively switching the information and the measured value, when the fault detector detects the second fault.
3. The measuring device as set forth in Claim 1, wherein when the fault detector detects a plurality of types of the first faults, the display controller allows

the display unit to display, instead of the measured value, information indicating the contents of the detected respective types of the first faults by sequentially switching the information with given blank display intervals interposed therebetween, and
5 wherein when the fault detector detects a plurality of types of the second faults, the display controller allows the display unit to display information indicating the contents of the detected respective types of the second faults by sequentially switching the information with the measured value interposed therebetween.
10

4. The measuring device as set forth in Claim 1,
15 wherein when the fault detector detects a plurality of types of the first faults, the display controller allows the display unit to display, instead of the measured value, information indicating the contents of the detected respective types of the first faults by sequentially switching the information with given blank display intervals interposed therebetween,
20 wherein when the fault detector detects a plurality of types of the second faults, the display controller allows the display unit to display information indicating the contents of the detected respective types of the second faults by sequentially switching the information with given blank display intervals interposed therebetween, after suspending the display of the measured value.
25
30
5. The measuring device as set forth in Claim 1,
35 wherein when the fault detector detects only the second faults, the display controller allows the display unit to display the measured value and information indicating the contents of the second faults.
40
6. The measuring device as set forth in Claim 5,
45 wherein when the fault detector detects the first fault and the second fault, the display controller allows the display unit to display the information indicating the content of the first fault and the information indicating the content of the second fault by sequentially switching them with a given blank display interval interposed therebetween.
50
7. The measuring device as set forth in Claim 1, wherein the display unit is made up of a segment group.
55

FIG. 1

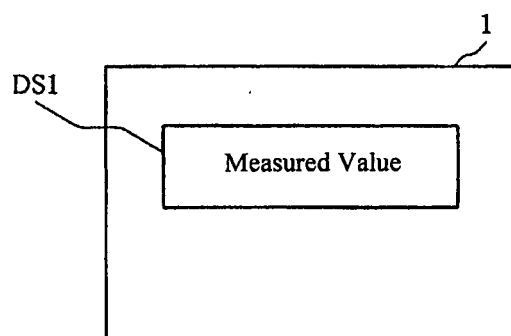


FIG. 2

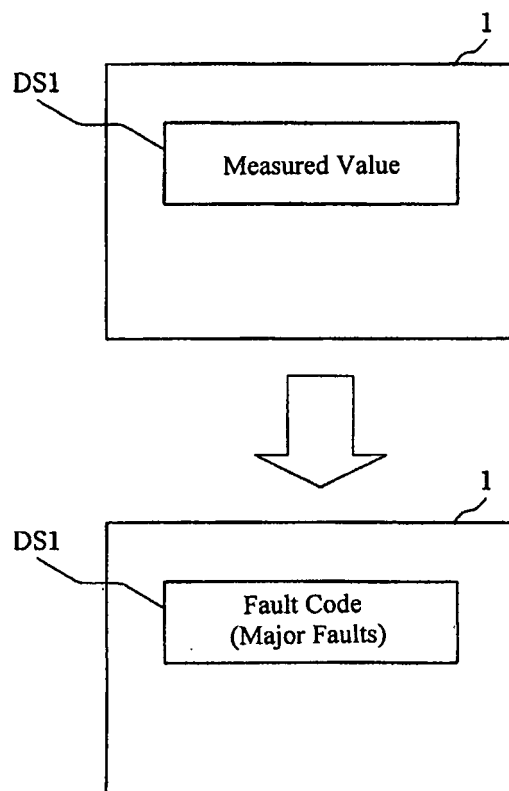


FIG. 3

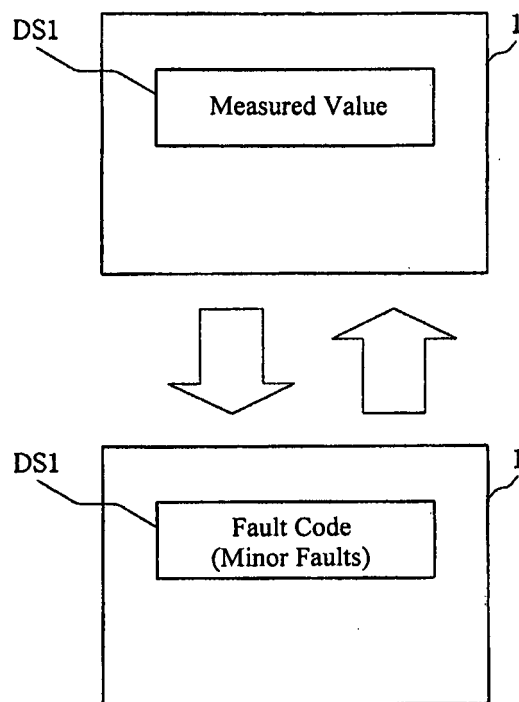


FIG. 4

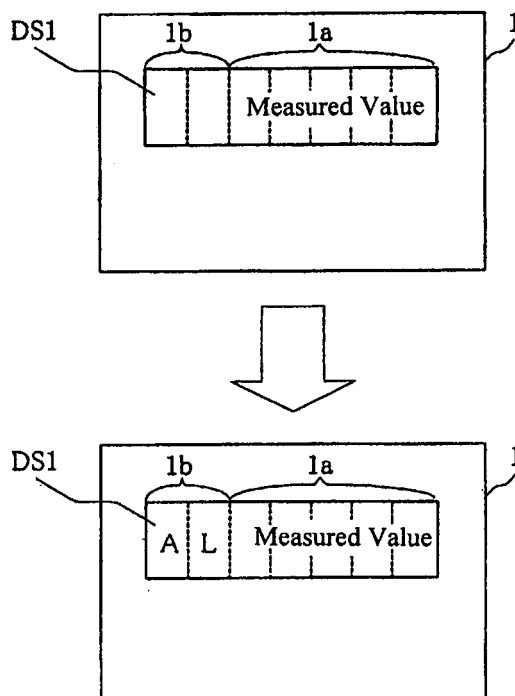


FIG. 5

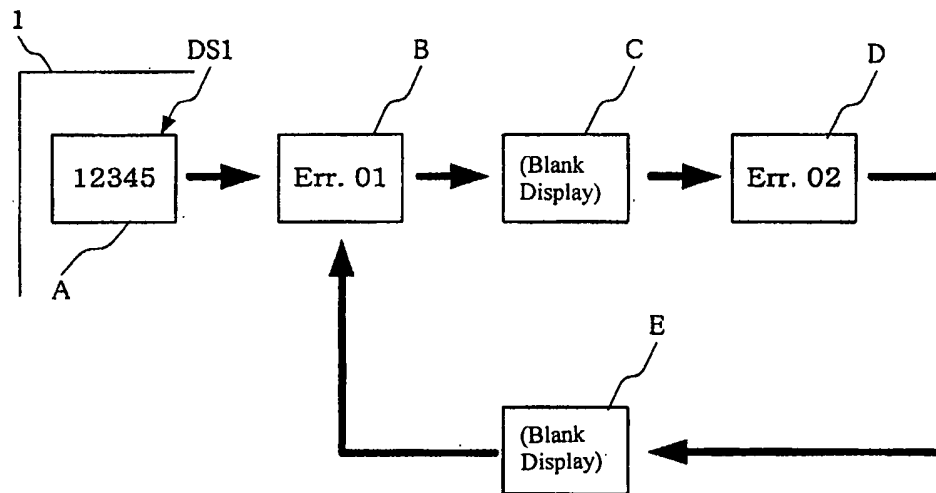


FIG. 6

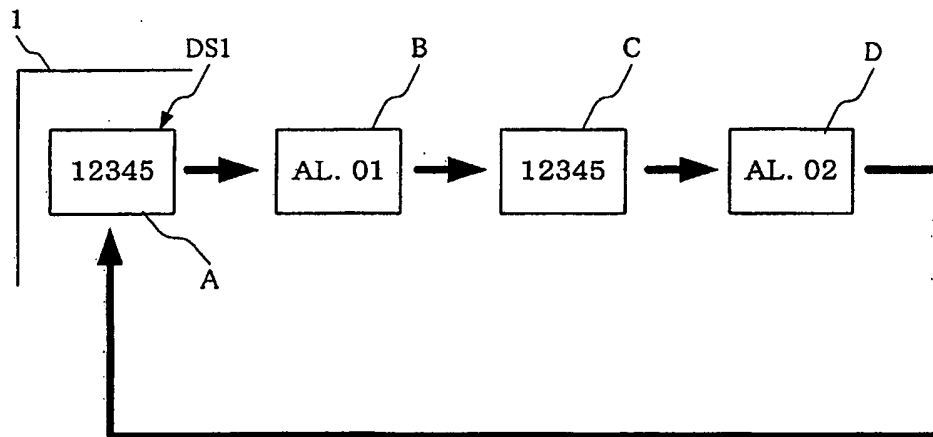


FIG. 7

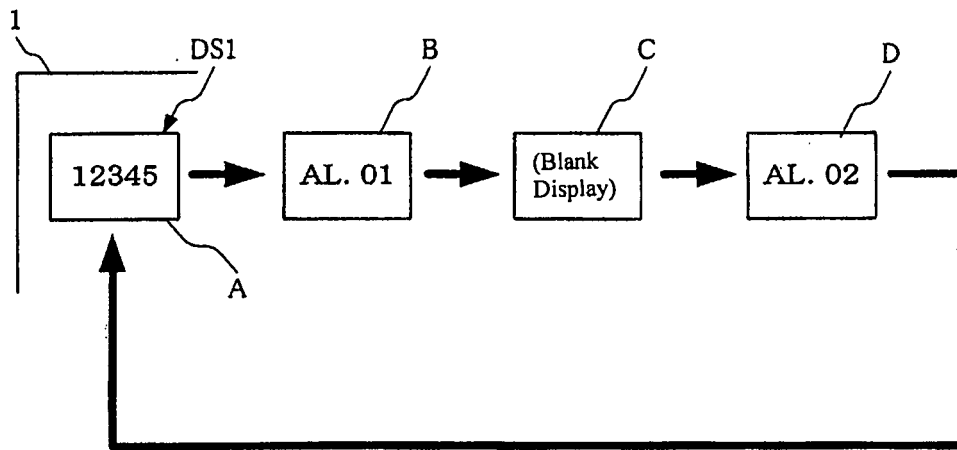


FIG. 8

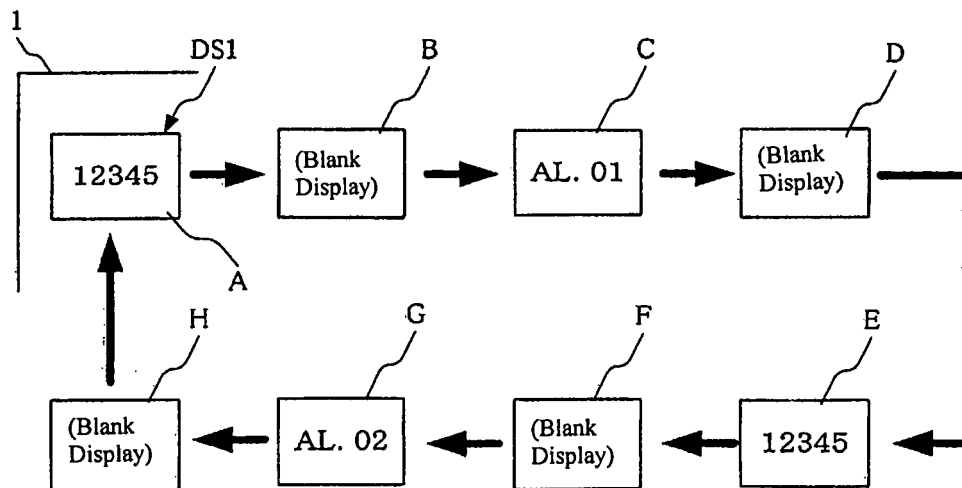


FIG. 9

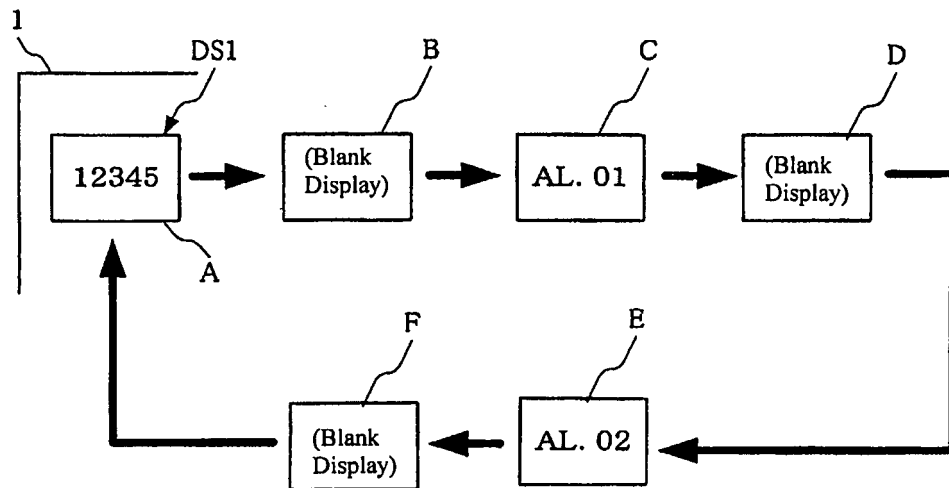


FIG. 10

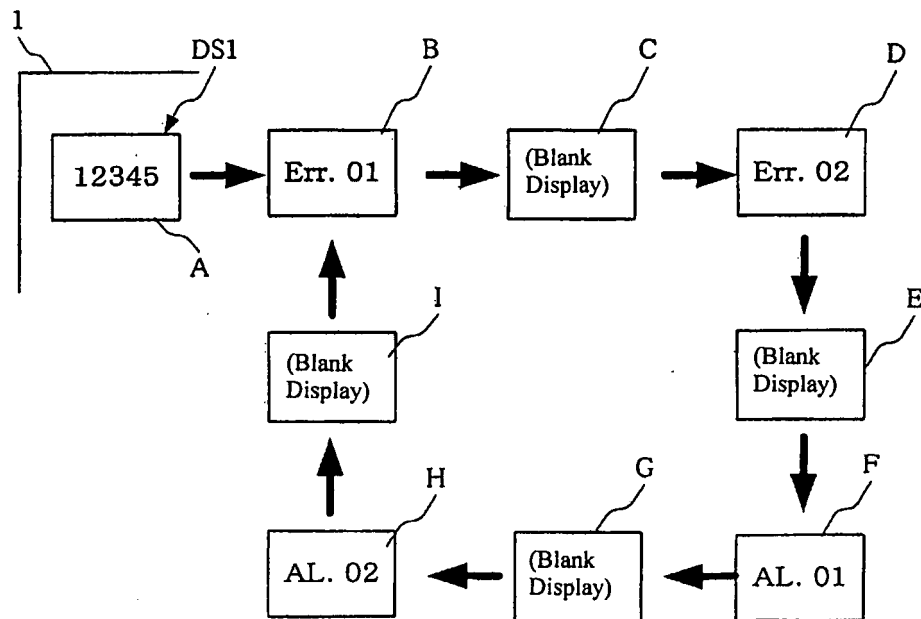


FIG. 11

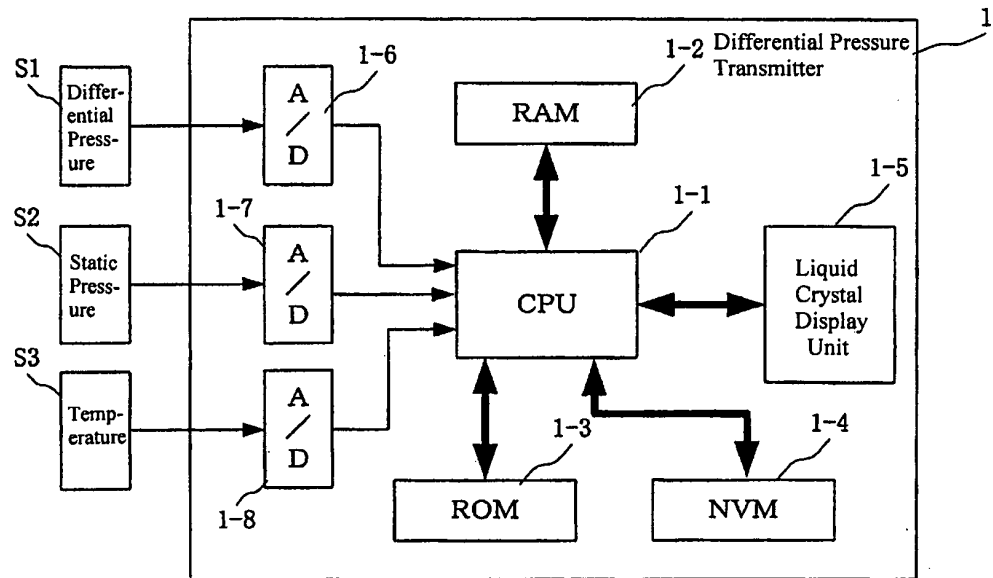


FIG. 12

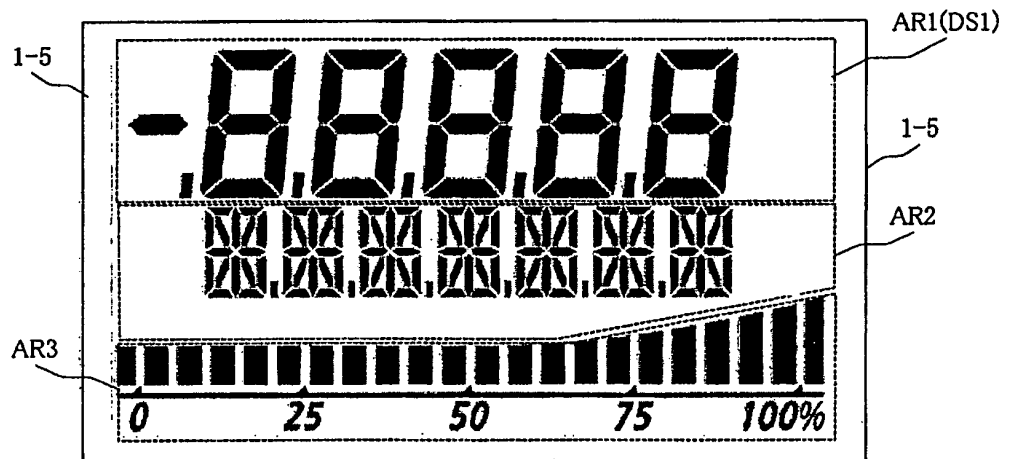


FIG. 13

Status Category	Detailed Status	Content of Display (A Box Indicates a Blank Space)
Normal	No Status	123.45
Major Fault	Major Fault (High)	Err.01
		Err.02
		Err.03
		Err.04
		Err.05
		Err.06
		Err.07
	Major Fault (Low)	Err.08

TB1

FIG. 14

Status Category	Detailed Status	Content of Display (A Box Indicates a Blank Space)
Minor Fault	Minor Fault (High)	□AL.01
		□AL.02
		□AL.03
		□AL.04
		□AL.05
		□AL.06
		□AL.07
	Minor Fault (Low)	□AL.08

TB2

FIG. 15

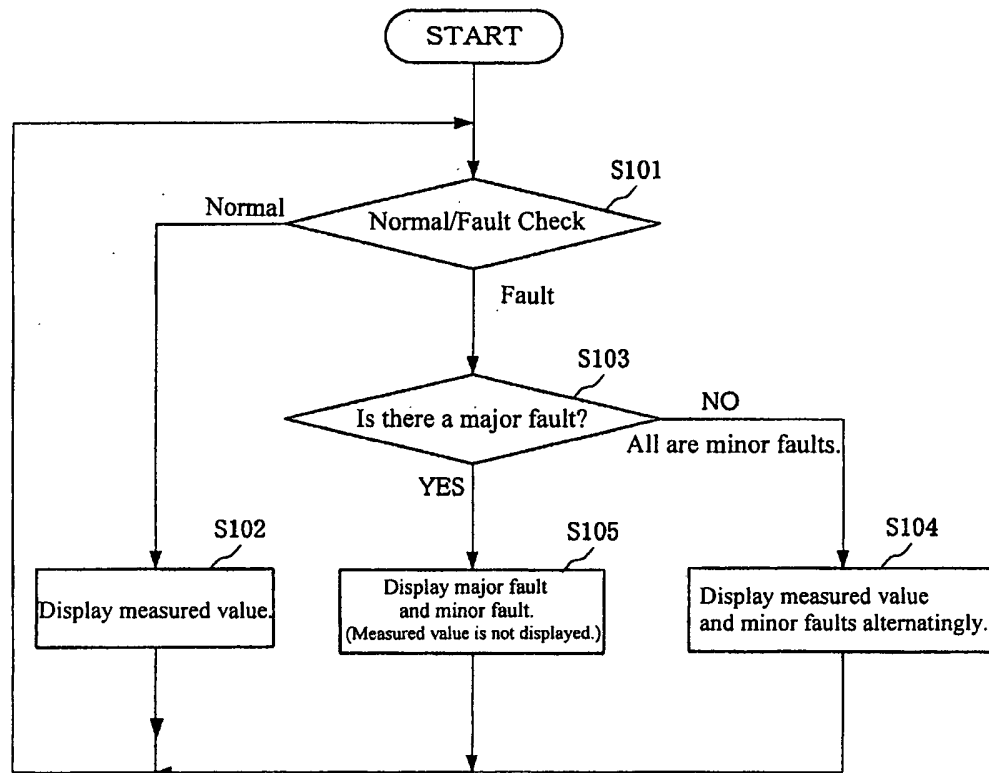


FIG. 16

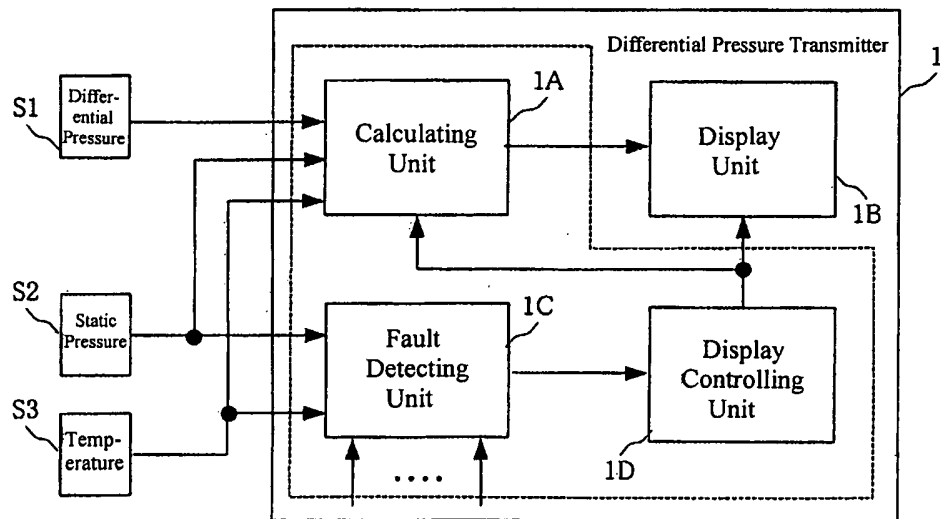


FIG. 17

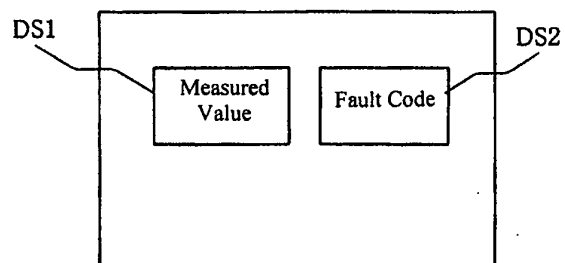
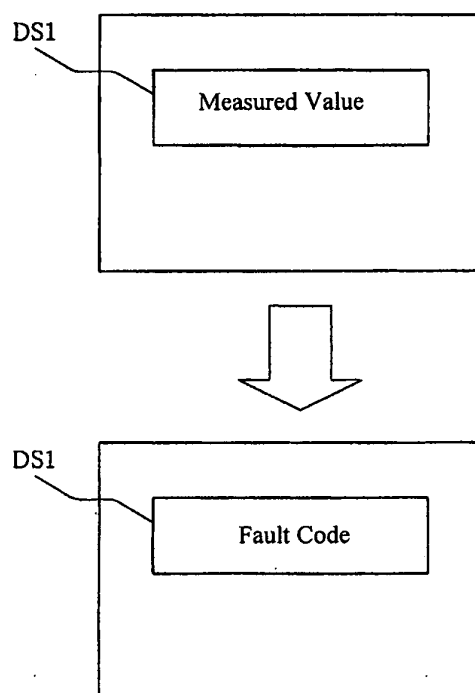


FIG. 18



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/071787

A. CLASSIFICATION OF SUBJECT MATTER

G01D7/00(2006.01)i, G01L19/12(2006.01)i, G08B23/00(2006.01)i, G05B23/02(2006.01)n

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G01D7/00-12, G01L19/12, G08B23/00, G05B23/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2009
Kokai Jitsuyo Shinan Koho	1971-2009	Toroku Jitsuyo Shinan Koho	1994-2009

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2-128115 A (Toshiba Corp.), 16 May, 1990 (16.05.90), Full text; all drawings (Family: none)	1-7
A	JP 60-246414 A (Matsui Mfg. Co., Ltd.), 06 December, 1985 (06.12.85), Full text; all drawings (Family: none)	1-7
A	JP 55-85997 A (Tokyo Shibaura Electric Co., Ltd.), 28 June, 1980 (28.06.80), Full text; all drawings (Family: none)	1-7

☒ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
29 January, 2009 (29.01.09)Date of mailing of the international search report
10 February, 2009 (10.02.09)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/071787

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 1-263793 A (Toshiba Corp.), 20 October, 1989 (20.10.89), Full text; all drawings (Family: none)	1-7
A	JP 4-315296 A (Komatsu Ltd.), 06 November, 1992 (06.11.92), Full text; all drawings (Family: none)	1-7
A	JP 2002-248967 A (Fuji Heavy Industries Ltd.), 03 September, 2002 (03.09.02), Full text; all drawings (Family: none)	1-7

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2000248967 A [0004]